1947

The stability of carotene and vitamin A in mixed poultry rations and the comparative efficiency of these components for egg production and hatchability.

Leonard Raymond Parkinson
University of Massachusetts Amherst

THE STABILITY OF CAROTENE AND VITAMIN A IN MIXED POULTRY RATIONS AND THE COMPARATIVE EFFICIENCY OF THESE COMPONENTS FOR EGG PRODUCTION AND HATCHABILITY

Leonard R. Parkinson

Thesis Submitted for the Degree of

Master of Science

University of Massachusetts
June, 1947

TABLE OF CONTENTS

PAGE

INTRODUCTION

Present Status of Vitamin A and Carotene in Poultry Feeding 1

Literature Cited 4

EXPERIMENTAL

Growth 9

Basal Rations 10

Methods Of Analysis 12

Egg Production and Hatchability. 13

Vitamin A Levels. 14

Carotene Levels 14

DISCUSSION

Storage Conditions 16

Losses of Carotene and Vitamin A - Plate I 17

Weight Data - Plate II 18

Feathering 19

Fleshing - Plate IV. 20

Vitamin A and Carotene in Egg Production 21

Egg Production Data. 21

Hatchability 22

Livability 23

SUMMARY. 25

BIBLIOGRAPHY 27

ACKNOWLEDGEMENTS 29

INTRODUCTION

Vitamin A exists as true vitamin A and may be derived from precursors of vitamin A. These precursors are the carotenes of carrots, greens and other vegetables and the cryptoxanthin of yellow corn. They are converted into vitamin A by the liver of the chicken. When true vitamin A is fed as found in a fish oil there is no question as to the conversion because it is used in this form. When alfalfa or other carotene sources are used as substitutes for vitamin A there is always the doubt as to whether it is converted to vitamin A and to what degree.

Vitamin A has been known to be essential for the life and good health of animals for some time. If the amount in the diet of young animals is too small they will stop growing within a short time and then begin to lose weight. With an insufficient quantity of vitamin A young animals may grow slowly but not make normal growth. Some of the diseases attributed to vitamin A deficiency are night blindness, sore eyes, susceptibility to respiratory infections and in extreme deficiencies convulsions may occur. An adequate supply of vitamin A is necessary for the growth of young animals and the production of eggs and healthy offspring. Vitamin A has a greater importance in animal feeding than was formerly supposed.

Vitamin A is a colorless substance that occurs in butter, eggs and the livers of fish and other animals. Carotene is a yellow

substance having vitamin A potency, when it is fed to animals and poultry and occurs in alfalfa, carrots, sweet potatoes and other yellow or green plants or plant products. Cryptoxanthin is a yellow substance occurring with carotene in yellow corn, and is also a precursor of vitamin A. Carotene eaten by animals may be converted into vitamin A which can be stored in the animal body, chiefly in the liver. Animals which receive abundant supplies of carotene or vitamin A are able to store enough vitamin A in the liver to last for several months, even though the feed used later may be deficient in vitamin A.

The knowledge of vitamin A has become more widespread and its importance in feeds for livestock and poultry more generally recognized by feed manufacturers. As a result many of these feed manufacturers have increased the vitamin A content of their feeds. This is particularly true in the case of poultry feeds. This has been done by the addition of carotene dissolved in oil, cod liver oils, fish oil concentrates or alfalfa meals high in carotene. It is known that both carotene and vitamin A are unstable. However, the exact relationship between the length of time of storage at different temperatures and the loss of carotene or vitamin A in mixed feeds has not been determined.

Alfalfa leaf meal usually constitutes from five to ten percent of a standard poultry ration. The industrial use of various green vegetables wastes is now under investigation. These studies

may produce results which will make possible the removal of valuable but relatively unstable components from the leaves before these components are destroyed by oxidation or some other action. The manufacture of stable concentrates may result from these investigations.

Both carotene and vitamin A are readily destroyed by light and exposure to air. It follows therefore that when oils or concentrates containing vitamin A are used in poultry feeds, there will be a gradual loss in the productivity of the vitamin A in the ration. The rate and extent of this loss will depend somewhat upon the type of ration and the storage conditions. The fact that losses in vitamin A potency occur in mixed feeds is an important consideration in the planning and mixing of rations.

Much research has been done in connection with these points but the literature shows some controversy on the subject. This study is an attempt to answer if possible some of the questions pertaining to this problem.

LITERATURE CITED

The ability of carotene to replace or act as a substitute for vitamin A in a poultry ration has been debated both pro and con for a number of years. Russell and co-workers (1939) stated that poultry were not particularly good converters of carotene to vitamin A. His opinion was based on figures obtained in earlier rat tests where the rate of conversion was found to be 0.6 micrograms of carotene being equivalent to 1.0 International Unit of vitamin A in biological activity. With this figure in mind he found that true vitamin A was absorbed at the rate of 85 to 96 percent in poultry whereas carotene was absorbed at the rate of but 60 percent on a high fat diet and only 25 percent on a low fat diet. This would indicate that true vitamin A is 1.4 to 3.8 times as effective for poultry as is the same U.S.P. unitage from carotene. If this is true, it would certainly be advisable to add an amount of true vitamin A to a poultry feed as a safety measure.

Peterson et al (1939) investigated quite thoroughly the action of the carotenoid pigments and their role in poultry nutrition. These workers fed carotene at a number of selected levels. Their general conclusions were that the hen was not an efficient converter of carotene to vitamin A.

Almquist, MacKinny and Mecchi (1945) in a series of experimental tests showed that the hen is an efficient converter of carotene. They fed the carotene at a constant level as contrasted

with Peterson (1939). They confirmed his findings on the low carotene content of the eggs. Almquist et al reasoned that the low carotene content of the eggs is not necessarily a criterion of the efficiency of carotene conversion. They found an increased amount of vitamin A in the egg yolks which they believed to be due to the carotene which they fed. Their conclusions were that carotene is efficiently converted into vitamin A by the hen and equivalent dietary levels of vitamin A potency in the form of carotene or of vitamin A lead to an equivalent deposition in the egg of vitamin A potency which is almost exclusively in the form of true vitamin A.

Williams, Lampman and Bolin (1939) using alfalfa meal as a source of carotene showed that carotene supplied in this form would satisfy the bird's requirement for vitamin A very efficiently. These investigators fed carotene at a level of 0.2 mg. per bird daily. This amount of carotene is equivalent to 333 International Units of vitamin A per day. Sherwood and Fraps (1934-35) came to essentially the same conclusions that Williams, Lampman and Bolin made in 1939. This lends more weight to the earlier work of Sherwood and Fraps.

Rubin and Bird (1946) published material on the apparent antagonism between vitamin A and carotenoids in the fowl. They claimed that vitamin A in fish liver oils is a pigment suppressing factor and that good pigmentation is suppressed when there is a sufficiently large body store of vitamin A. Carotene fed at com-

parable levels had no suppressing effect on pigmentation.

Wells and Davidson (1940) in their studies in this field concluded that when carrots are available and alfalfa products of good quality are not available, or are available at higher prices, the flock owners may use carrots with reasonable chance of supplying the laying birds' needs for green feed and carotene or vitamin A during the winter months.

Fraps, Meinke, Reiser and Sherwood (1943) pointed out that certain types of feed have carotene consuming power which would necessarily have an effect on any carotene which might have been added to the feed. Some of the materials reputed to have this carotene consuming power are skim milk powder, meat scraps, tankage and dried fish. Vegetable feeds seldom have any carotene consuming power. Feeds of high carotene consuming power may sometimes cause injury to chickens through vitamin A deficiency if the ration is low in carotene or vitamin potency, otherwise, a high carotene consuming power does not seem to be injurious.

It has been reported from some unpublished data from the Purina Mills Research Laboratory (1946) that carotene concentrates cannot be used successfully to replace vitamin A in poultry rations as the rate of deterioration is too great. Fraps and Kemmerer (1937) report that the opposite is true, that is, that vitamin A deteriorates more rapidly in feeds than does carotene. Their investigations showed that in a period of four weeks from 70 to 100 percent of the

vitamin A added to the mixed feeds disappeared, when stored at either 4°C. or 28°C. Feeds stored in small amounts lost their vitamin A as rapidly as feeds stored in large amounts. They found that carotene from alfalfa was much more stable than vitamin A at room temperature. Carotene values decreased from 6 to 70 percent in eight weeks.

Bethke, Record and Wilder (1937) concluded that the carotene content of a mixed ration declines at the start of the storage period but after this initial drop the value stays quite constant. The vitamin A content decreases from the start and declines continously until gone. These workers also state that the same number of International Units have the same effect on chickens whether fed as vitamin A or as carotene. This does not agree with Russell (1939) but is in agreement with some of the results of the present study.

In 1932 Sherwood and Fraps set up a series of experiments to determine the requirements of vitamin A for pullets, maintainance and egg production. These investigators placed a unit requirement for the above mentioned factors. They expressed their results in rat units of vitamin A which is rather difficult to interpolate into present day figures. Sherwood and Fraps (1935) continued their earlier experiments and found that the requirements for White Leghorn pullets was about 600 Sherman-Munsell units per pound of feed. This is equivalent to approximately 2000 International Units of vitamin A per pound of feed. The method used for the determinations for vita-

min A content was the rat growth method and it is admitted that this method may be inaccurate to a considerable extent.

Sherwood and Fraps (1936) concluded that the carotene requirements of growing chicks might be as high as 220 micrograms of carotene per 100 grams of feed. This amount is equivalent to approximately 1320 International Units per 100 grams of feed.

Ringrose and Norris (1936) reported that about 700 International Units of vitamin A per pound of feed were required by the chick up to eight weeks of age while Schroeder, Higgins and Wilson (1935) reported that 6000 International Units of vitamin A per pound were required. In 1936 these same workers reported that 1200 International Units were sufficient. Thus it can be seen that a wide divergence of opinion prevails among the many investigators in this field.

Ewing (1943) in his book on poultry nutrition shows a table (pp.488-90) which gives the results of a large number of carotene stability tests under many conditions. Under optimum conditions of refrigeration no carotene will be lost from mixed rations, but under average storage conditions about 50 percent is usually lost.

EXPERIMENTAL

Growth

The first part of this experiment was set up with the idea of showing the effect of typical farm storage conditions on the stability of carotene and vitamin A in mixed rations. This effect might have been determined by simply running periodically a series of chemical analysis. However, it was felt that added weight might be assigned to the results if several groups of day-old chicks were fed these rations for a period of twelve weeks. The early part of this period is the critical stage of a chick's life and at the twelve-week interval young poultry are usually marketed as broilers. It was decided to use three groups of 50 chicks. One group (A), the control group, was fed the basal ration plus an adequate vitamin A supplement. This supplement was supplied at a level of 2000 International Units of vitamin A per pound of feed. This figure was about average of all the figures found in the literature and it was felt that this amount would give a substantial response to the chemical analysis.

A second group (B), was supplied the same basal ration but in place of any vitamin A, a carotene supplement extracted from alfalfa was supplied. This was fed at a level equivalent to 1228 International Units of vitamin A per pound. This level was selected as it was lower than any level reported in the literature. If the biological activity of carotene to vitamin A is 0.6 micrograms

of carotene is equal to 1.0 International Unit of vitamin A, then the vitamin A fed as carotene in this group should produce somewhat less growth than that in group A.

The third group (C), of 50 chicks was given the same basal ration as the other two groups but was supplied carotene in place of vitamin A equivalent to the same feeding level of vitamin A as group A. That is, the carotene in this group was fed at a level of 2029 International Units of vitamin A per pound of feed. Therefore, this third group could be expected to show approximately the same growth response as group A, if poultry are as efficient as rats at converting carotene to vitamin A for growth purposes. The amount of feed consumed by A and C was approximately the same while group B was somewhat less.

The three groups of chicks were weighed periodically throughout the test period. Observations were made regarding feathering and pigmentation (shank color); at the end of the twelve-week period the three groups of birds were graded as to fleshing and feathering.

The Basal Rations	Starter-Grower	Layer
Ground wheat	40.0%	42.5%
Ground oats	25.0%	25.0%
Wheat bran or wheat midds	15.0%	12.5%
Soy bean meal	10.0%	10.0%
Meat scraps	7.5%	7.5%
Calcium carbonate	1.0%	1.25%
Steamed bone meal	1.25%	0.5%
Iodized salt	.5%	.5%
Manganous sulphate	½ oz.	½ oz.
Delsteral	2 oz.	2 oz.
Protein by analysis	18.6%	19.35%

Most research workers in the field have used a different basal ration than was used in this project. In the majority of cases white corn meal has been substituted for yellow corn meal. Due to war emergency conditions, no white corn was available. This necessitated a substitution of ground wheat and oats in place of the white corn. The substitution seemed to answer the nutritional requirements of the chickens satisfactorily.

Methods of Analysis

The whole feed sample is extracted with peroxide free ethyl ether for four hours in a Soxhlet apparatus. The residue is saponified and again extracted with ethyl ether. After evaporating the non-saponified fraction under nitrogen, it is then dissolved in chloroform. An aliquot is taken for vitamin A determination by the reaction with antimony trichloride. A similar aliquot is evaporated down and taken up in Skellysolve F for carotene analysis. The Skellysolve solution is stripped about eight times with 90 percent methanol and dehydrated by filtering through anhydrous sodium sulphate. The solution is then read on a colorimeter using a 440 mu filter and the carotene calculated from a curve based on SMA crystalline carotene.

Another somewhat different method was used and the results obtained were in very close agreement with the former.

A 5 gram sample is refluxed for one half hour with 50 ml. of freshly prepared alcoholic KOH (50 g. in 200 ml. alcohol) and 5 grams anhydrous sodium sulphate. The solution is cooled to room temperature and decanted into a 500 ml. separatory funnel. The residue is extracted by shaking and decanting with at least three portions of 35 ml. of Skellysolve B until extracts were colorless. The extracts were combined with the alcoholic KOH extract and washed with 90 percent methanol shaking thoroughly after each addition until washings were colorless. The Skellysolve is then

washed with water until free of KOH and filtered through anhydrous sodium sulphate. The filtrate is then passed through an adsorbent column of activated magnesium oxide and Hyflo Super-Cel according to the method of Wall and Kelly, Ind. & Eng. Chem., Anal. Ed. 15, 18(1943). The eluate is then diluted to a convenient volume and carotene content determined by measuring the percent transmittance in a spectrophotometer.

Egg Production and Hatchability

The second phase of this experiment was to investigate the effect of carotene versus vitamin A in poultry rations during winter feeding when no fresh greens or range are available. A series of three pens of Rhode Island Red pullets containing about 140 birds each was used. This starting number was reduced somewhat during the test feeding period by natural mortality, removal of certain birds for breeding, etc. The average number throughout the period was about 100 birds in each pen. The first of these groups, (D), was fed a basal ration containing no vitamin A or carotene, but supplemented with 1000 International Units of vitamin A per pound of feed. This vitamin A was obtained as pure vitamin A in an oil base. Group D was considered to be the control group. The 1000 International Units of vitamin A per pound was decided on as it was a lower figure than the lowest reported in the literature reviewed. It was thought that this level would produce typical vitamin A deficiency symptoms.

A second group of these pullets was provided the same basal ration. This was supplemented with pure vitamin A from the same source as the first group but offered at a level which would provide ample vitamin A for body maintenance and egg production. The level decided upon was 3000 International Units per pound. This figure was generally accepted throughout the literature as an optimum level. The third group, (F), was fed the basal ration plus a carotene level equivalent to 3000 International Units of vitamin A per pound. This was equal to the 3000 International Units of vitamin A per pound which was fed to group E. If the ratio of 0.6 micrograms of carotene to 1.0 International Unit of vitamin A in biological activity for the rat holds true for poultry, then this level of vitamin A in the form of carotene should produce approximately the same results.

The basal ration for this part of the experiment was mixed fresh every four weeks. The carotene and vitamin A content was determined after each mix. In this manner the carotene and vitamin A content was maintained at a relatively constant level. No storage factor was involved and subsequent analysis showed that the values of these components from batch to batch was approximately the same. The same method for carotene and vitamin A analysis was used as has been described earlier.

At the latter end of the experimental period, eggs were collected from the test groups and placed in an incubator. This

was done to see if there was any difference in the hatchability figures of these three groups.

White Rock males were added to each group about three weeks before the egg colections were made.

DISCUSSION

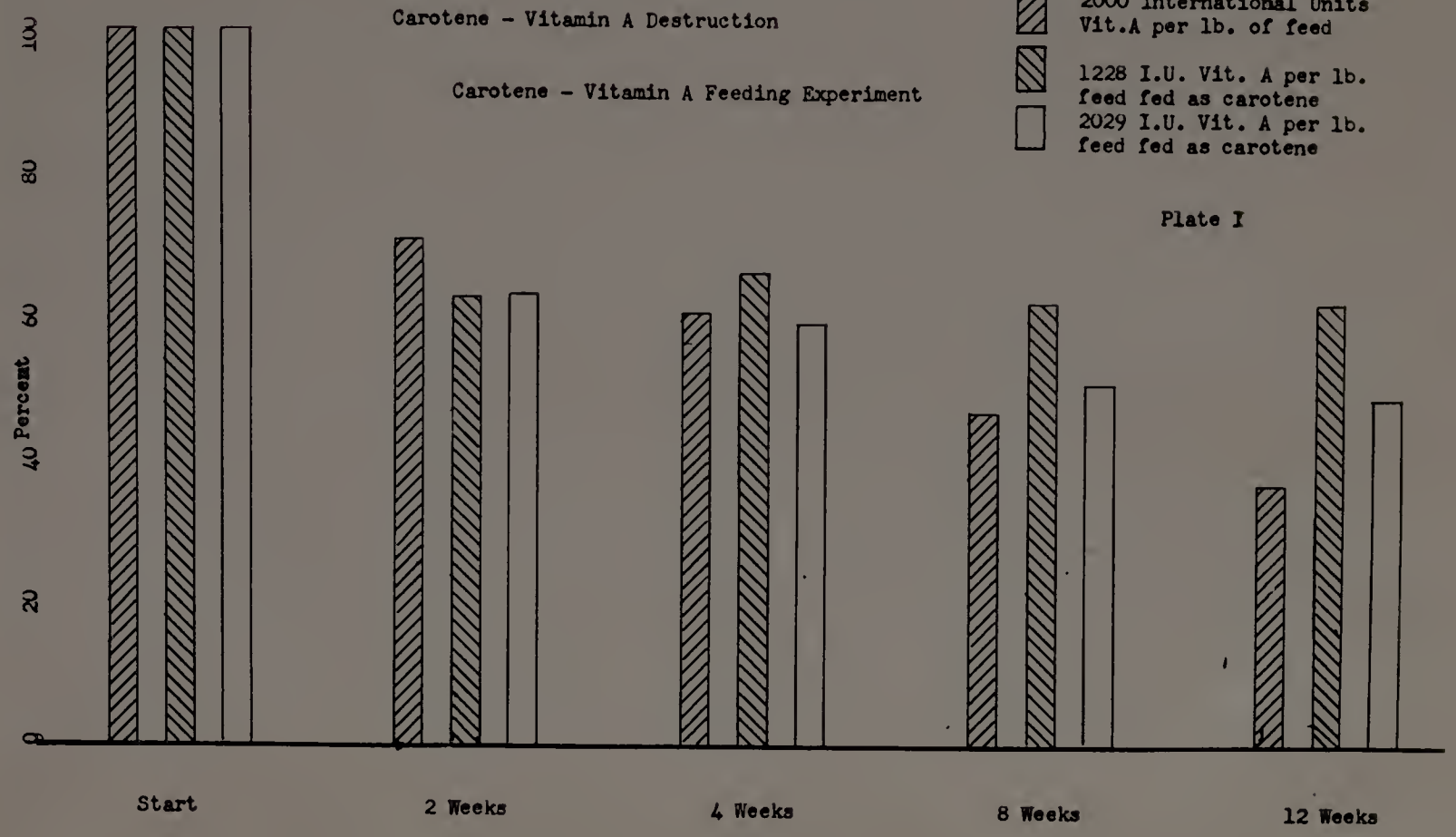
The most important consideration in the first part of this experiment was whether or not the carotene content of the rations varied as greatly as the vitamin A and secondly, whether this variation was detrimental to the welfare of the test birds. The feed was stored in the same house in which the chicks were reared. The chicks were started under brooders but the house itself was supplied with supplementary heat. The minimum temperature in this house was about 70°F. throughout the test period and the maximum approximately 85°F. These storage conditions, which the feed was subjected to, were certainly unfavorable for preserving the carotene and vitamin A content.

Plate I gives a graphic illustration of the rate of deterioration of both the carotene and vitamin A content of the ration. The control ration (A) lost 27% of its vitamin A in the first two weeks. At four weeks 39% had disappeared. The rate of loss continued progressively downward and at eight weeks only 47% of the original amount remained while at the end of the experiment (12 weeks) all but 37% had been destroyed. The slope of the curve indicates that the loss of vitamin A would probably continue until it was entirely gone. This supposition is confirmed by Fraps and Kemmerer (1937).

The case of the carotene is somewhat different. Group

B, which was fed the equivalent of 1228 International Units of vitamin A in the form of carotene from an alfalfa extract, showed a markedly less weight response to their basal ration than did group A. Referring to Plate I, it is easily seen that the initial loss of carotene is of a greater percentage than that of the vitamin A (38.5% versus 27%). However, after this initial loss the rate of deterioration of the carotene is considerably slower. In the case of group B there was an apparent increase in carotene content at the end of four weeks. It seems that this unusual situation may have been an error in the chemical analysis or in sampling and little significance should be placed on it. The following determinations showed that there was no net loss after the initial drop. It would seem that carotene was more stable than vitamin A in this case.

The basal ration fed to group C contained the equivalent of 2029 International Units of vitamin A per pound as carotene from the alfalfa extract, showed a sharp initial drop as did B and the subsequent analysis indicated that the rate in which the carotene in this ration disappeared was more rapid than group B but somewhat slower than group A. It might be concluded from Plate I that carotene from alfalfa extract in mixed rations deteriorates more rapidly than vitamin A during the first two weeks but thereafter the vitamin A disappears much more rapidly. The carotene content has a tendency to stay relatively constant.


Carotene - Vitamin A Destruction
Carotene - Vitamin A Feeding Experiment
2000 International Units Vit.A per lb. of feed
1228 I.U. Vit. A per lb. feed fed as carotene
2029 I.U. Vit. A per lb. feed fed as carotene
Plate I
Percent
0
20
40
60
80
100
Start
2 Weeks
4 Weeks
8 Weeks
12 Weeks

A poultryman is principally interested in how quickly and economically he can raise day-old chicks to broiler size (3-4 lbs.). Any factor which might be added to a broiler ration or substituted for a more expensive component in the ration would be of definite value.

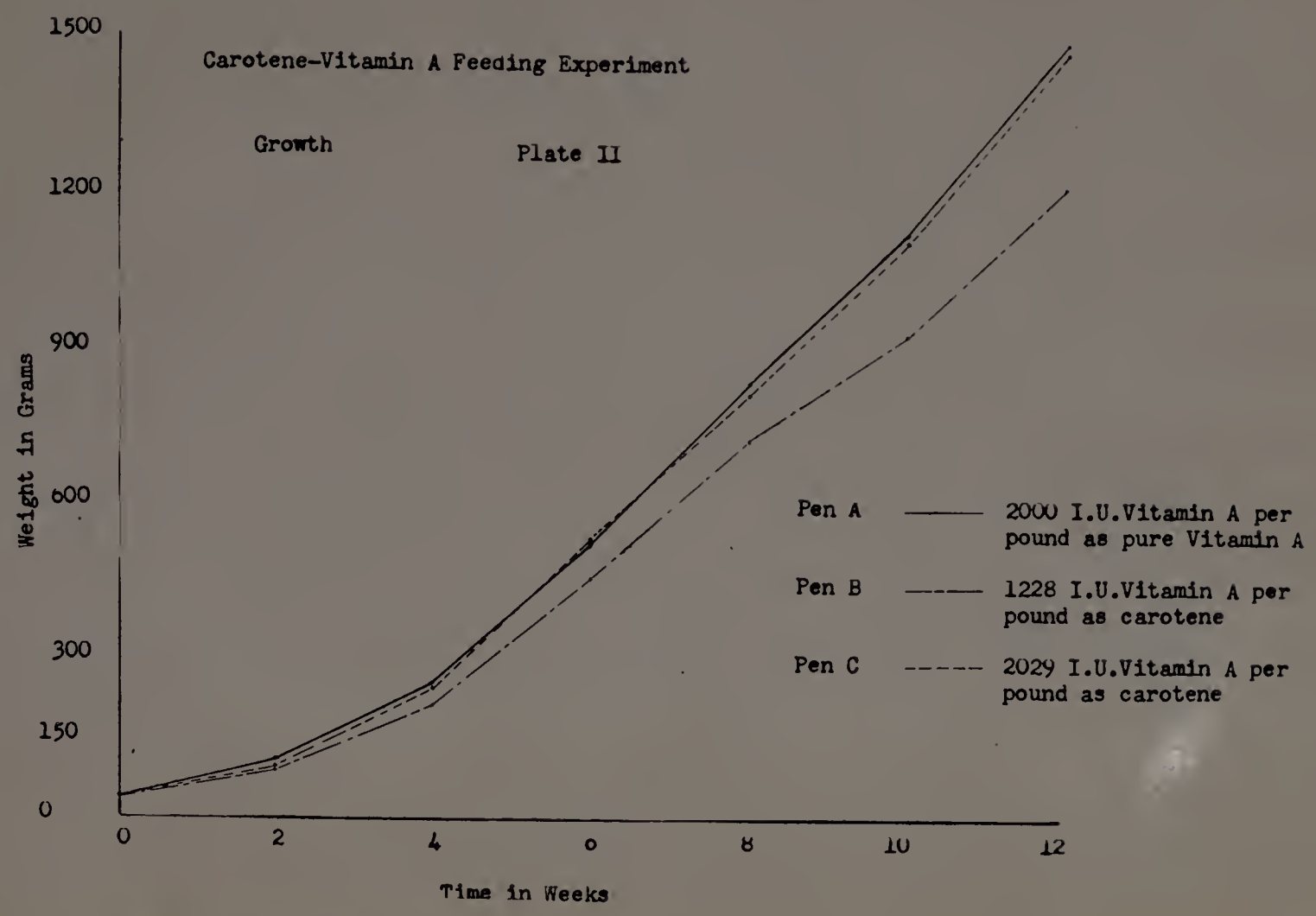
Plate II illustrates graphically the gains in weight throughout a 12-weeks growing period. It is clearly evident that the gains in weight of groups A and C are practically the same. These two groups were fed equivalent amounts of vitamin A (2000 I.U.) except that group A's was supplied as pure vitamin A and group C's was supplied as a carotene concentrate from alfalfa. These figures seem to indicate that where vitamin A and vitamin A supplied as carotene are offered at the same level that good growth and development will be obtained. It is an established fact that 0.6 micrograms of carotene are equal to 1.0 International Unit of vitamin A in biological activity for the rat. This seems to be equally true in poultry, if one uses body weight as the standard.

In considering group B which received vitamin A in the form of carotene at about a 33 percent lower level than that received by group A, a very different result was evidenced. Plate II shows that the rate of growth was slower. This was probably due to a smaller feed consumption, but this in turn can doubtless be traced to the ration being slightly inadequate in vitamin A

Carotene-Vitamin A Feeding Experiment

Growth

Plate II

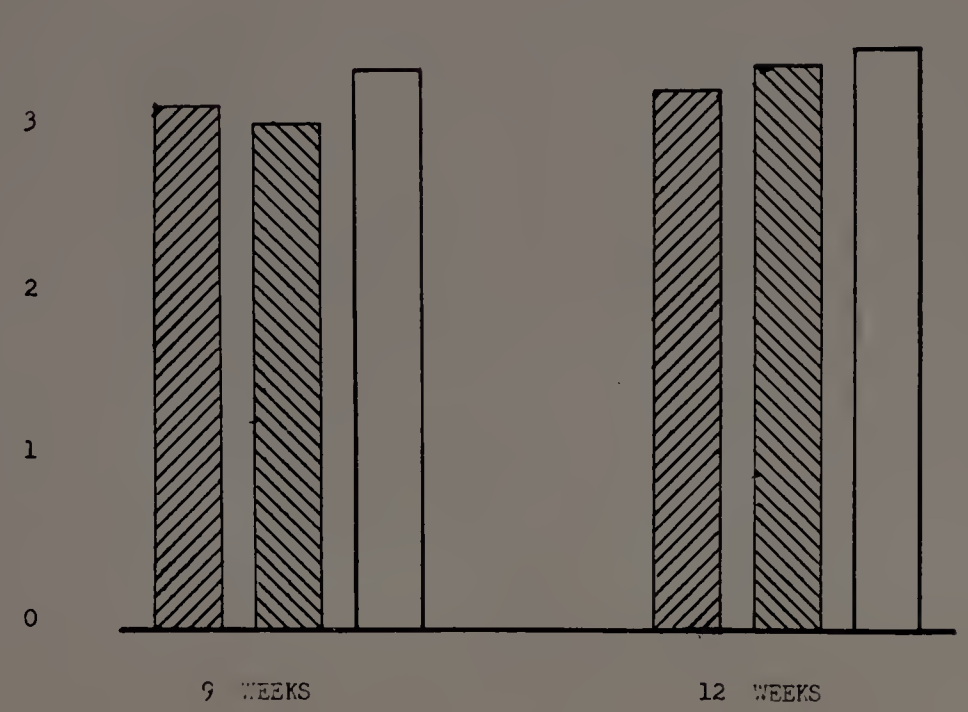


content. If poultry are no more efficient converters of carotene than are rats, then the supply of carotene in this ration should have been inadequate. This seemed to be true as this group grew more slowly and had more birds which were not uniform.

One might conclude that growing birds need more vitamin A than the 1228 International Units of vitamin A supplied in their rations from carotene extract of alfalfa. Group B contained more pullets than either of the other two groups but when one evaluates the weight data on a sex basis this group is still decidedly inferior.

Rapid and complete feathering is a desirable characteristic in broiler production. Plate III shows the degree of feathering in these three groups of birds. At the nine-week interval group A was slightly superior to B but neither was as well feathered as group C. This picture is changed slightly at the 12-week period as B is now a bit better feathered than A, but both groups are behind group C. Group B's spurt at the end is probably due to a predominance of pullets. Pullets always feather up earlier than cockerels. This factor was not enough to offset the feathering advantage of group C. The feeding of carotene in broiler rations as a source of vitamin A seems to produce better feathering at 3 months than vitamin A supplied as pure vitamin A. The method of Hays and Sanborn (1942) was followed in determining the degree of feathering.

Feathering Carotene - Vitamin A Feeding Experiment Plate III



Pen A — 2000 International Units per pound of feed fed as pure vitamin A

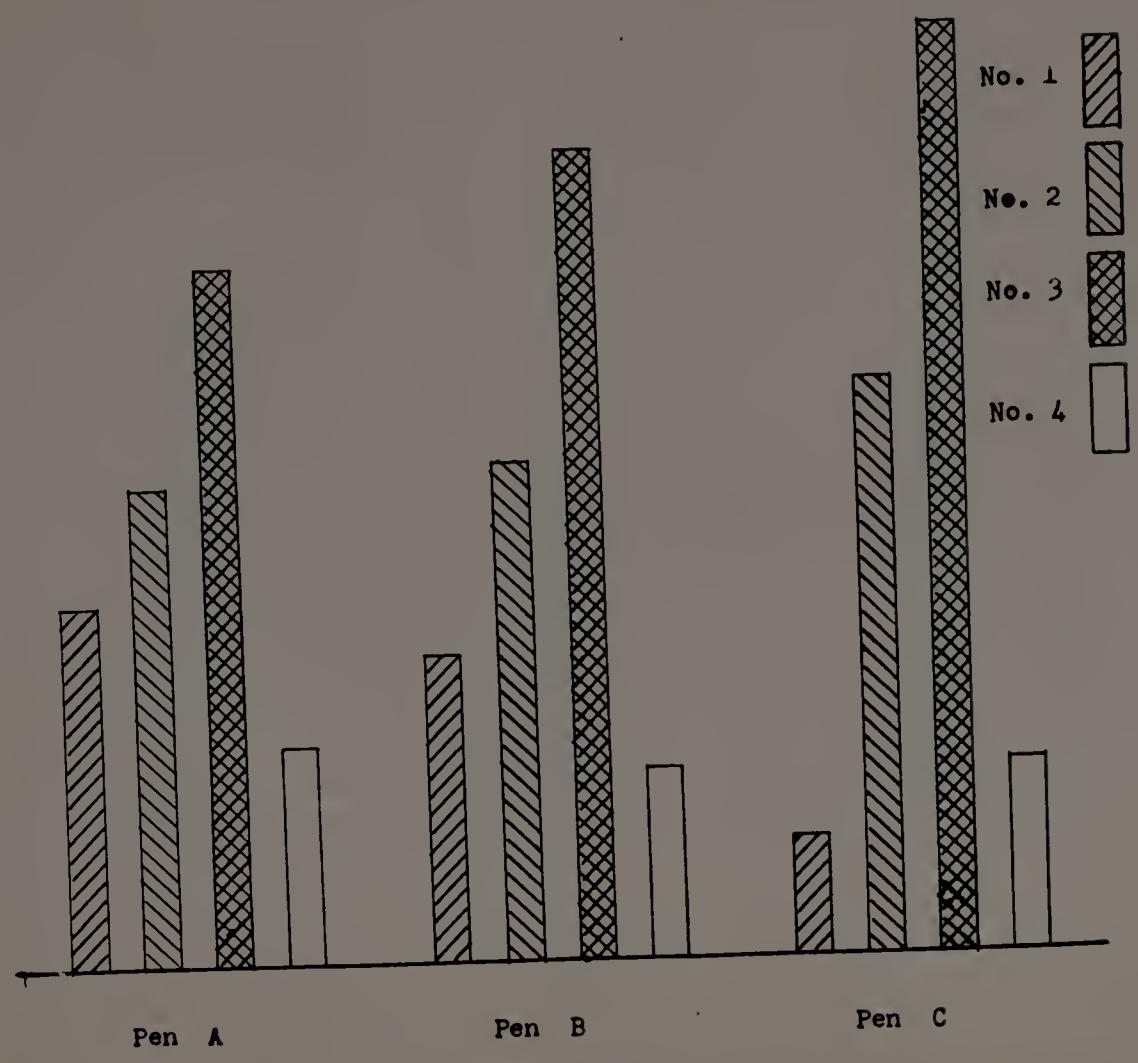
Pen B — 1228 International Units Vitamin A per pound of feed fed as carotene

Pen C — 2000 International Units Vitamin A per pound of feed fed as carotene

1. Bare to 25 percent feathered
2. 25 percent to 50 percent
3. 50 percent to 75 percent
4. Full feathered

The birds in these three groups were graded as to their fleshing qualities at the end of the 12-week period. Plate IV shows that there were more top quality (No.1) birds in A and fewer in B and less in C, but the No.2's were about the same in A and B but slightly higher in C. Group C had many more medium fleshed (No.3) birds than either of the other two groups. The three groups were all about the same in regard to the poor quality birds. It could be concluded from this graph that just as good fleshing can be obtained by using carotene in broiler rations as a source of vitamin A.

Pigmentation (shank color) observations were made periodically during the test. While pigmentation is reputed in no way to affect the health of the birds it does increase their sales appeal. The shank color of the birds in all three of the groups was extremely pale. It was evident that there was a lack of the element in the basal ration which is thought to be responsible for the development of the yellow colored shanks. Cryptoxanthin, found in yellow corn, which normally makes up approximately 30-40 percent of a poultry ration, is believed by many investigators to be largely responsible for this phenomenon of shank color.



Fleshing Carotene-VitaminA

Feeding Experiment

Plate IV

Vitamin A and Carotene in Egg Production

The second part of this carotene-vitamin A project involved the feeding of three pens of laying pullets on specific levels of carotene and vitamin A.

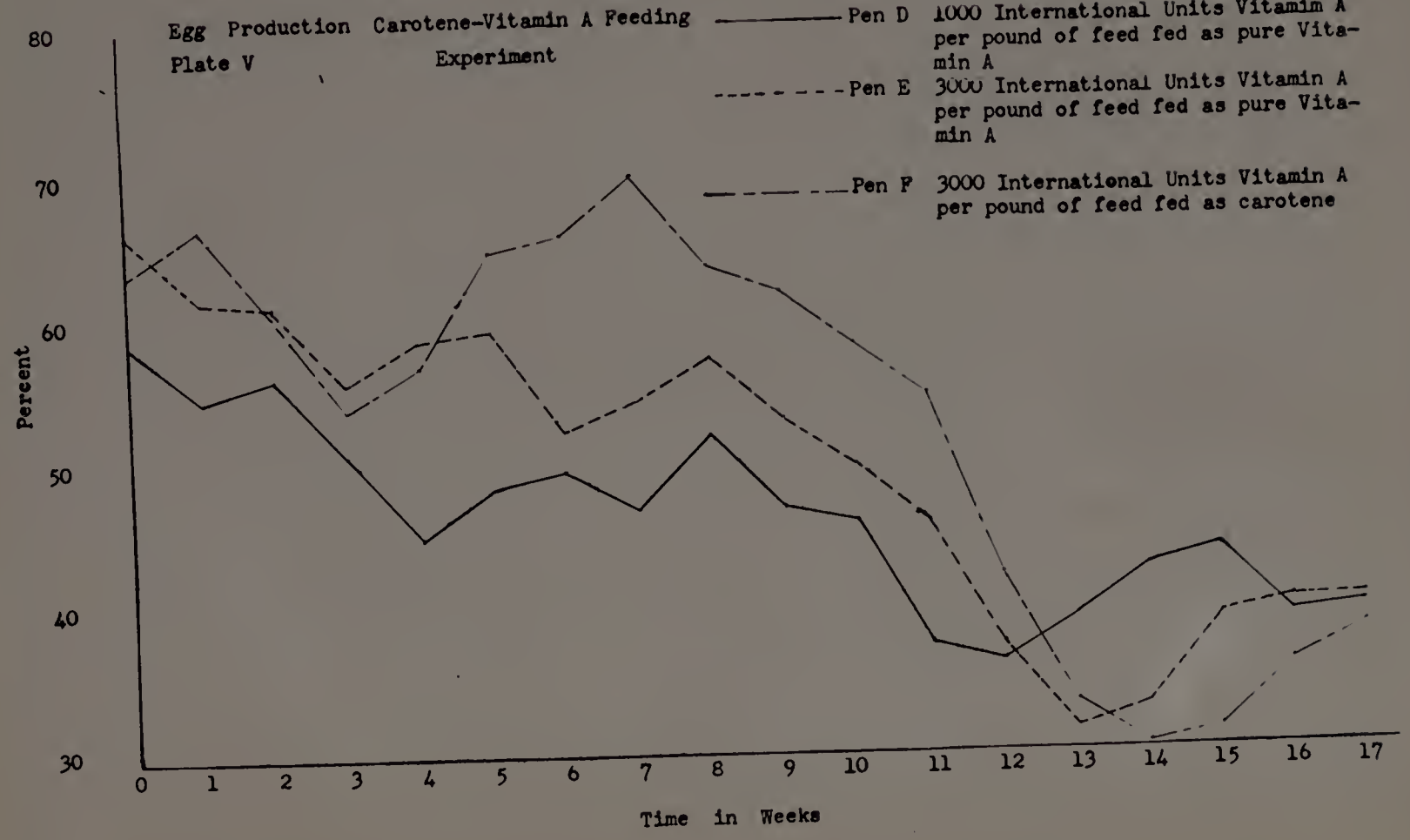
Plate V shows that at the start of the experiment all the groups of pullets were laying at approximately the same rate. By the end of the first month pen D had fallen off in egg production whereas the other two pens were on the increase. This condition was expected in view of the low level of vitamin A received by pen D. At the six-week interval group F, the carotene group, had made a great increase over the other two pens. Two weeks later all the pens were approaching about the same level of egg production. At the end of the test period the laying percentages of all three groups were within three percent. This data seems to indicate that the lower level of vitamin A (1000 I. U. per pound) was adequate for satisfactory egg production and that there is no advantage in feeding three times as much, as was the case in pen E.

Pen F, over the entire period, produced more eggs than either of the other two groups. Indications are that when carotene is supplied at the same rate as vitamin A in a poultry ration egg production will remain at a satisfactory level.

The general health of all the birds was satisfactory.

Egg Production Carotene-Vitamin A Feeding Experiment

Plate V



At the end of the experiment all birds were killed and it was noted that none of the birds could be considered to be fat. The lack of corn in the basal ration is probably largely responsible for this condition.

The data obtained indicate that carotene from an alfalfa concentrate will give equally good results as pure vitamin A when used in a poultry ration and fed at a level of not less than 0.6 microgram to 1.0 International Unit of vitamin A.

It could be concluded that poultry are just as efficient as converters of carotene as rats, if egg production is to be used as a standard.

It must be considered that these rations were stored under winter storage conditions. That is, the feed was kept in an unheated building. It is doubtful if any appreciable quantity of either vitamin A or carotene would be destroyed under these conditions.

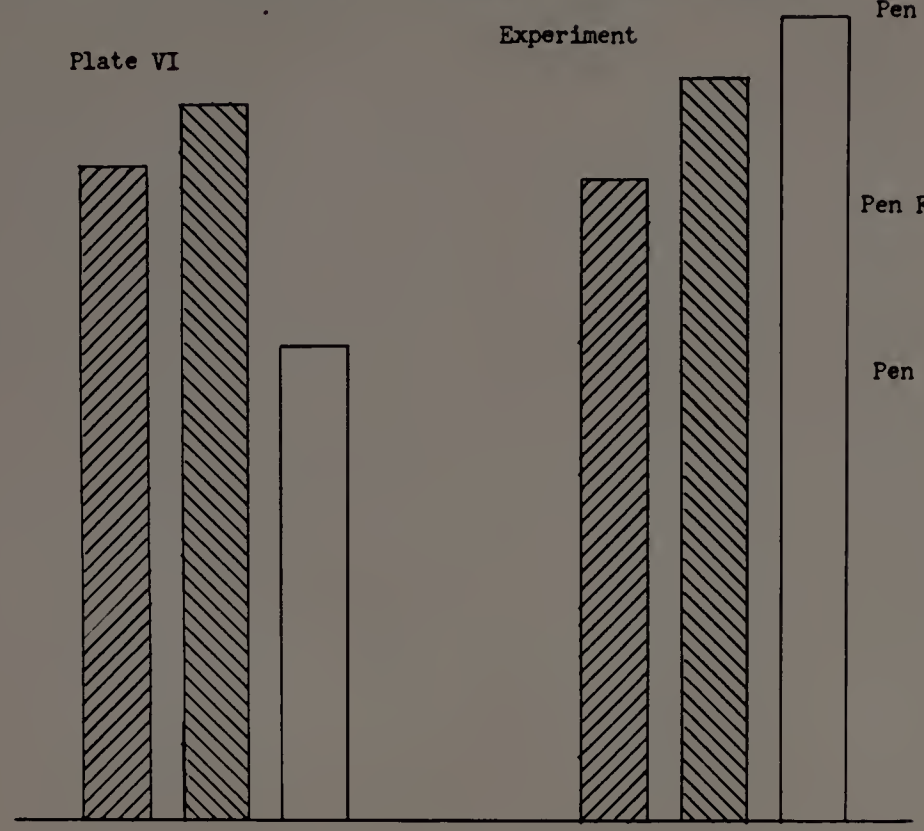
Plate VI illustrates the percentages of hatchability and fertility of these groups. In pen E (3000 I.U. vitamin A per pound), the fertility was 79 percent. Pen F (3000 I.U. vitamin A per pound fed as carotene), 86 percent and pen D (1000 I.U. vitamin A per pound), the fertility was but 58 percent. The percentages of fertility in pens E and F are about normal but the percent in pen D is considerably below normal. It is not thought that much weight

Fertility and Hatchability

Plate VI

Carotene - Vitamin A Feeding

Experiment



Pen E — 3000 International Units Vitamin A per pound of feed fed as pure vitamin A

Pen F — 3000 International Units Vitamin A per pound of feed fed as carotene

Pen D — 1000 International Units Vitamin A per pound of feed fed as pure vitamin A

should be placed on these fertility figures as the number of cockerels to pullets was less in pen D than in the other two. These fertility results are given just as a matter of interest.

The hatchability figures are quite intersting in that they are all good. Pens F and D are higher than is usually obtained, but the figure for pen E is 77.2 percent which is practically the same as the flock average here at the University. These figures would seem to indicate that good hatchability can be obtained when as low a level as 1000 International Units of vitamin A per pound of feed is supplied. There does not seem to be any advantage in feeding any more than this amount if one considers hatchability as a criterion.

It was thought that the chicks from these three hatches might show a difference in regards to their vitality. Consequently they were placed under brooders in separate groups and fed a commercial starting ration. A record of the number of chicks which died was kept. In pen E (3000 I.U. vitamin A per pound) and pen F (3000 I.U. vitamin A per pound fed as carotene concentrate) the mortality was approximately 2 percent, which is generally considered to be normal. The chicks from pen D (1000 I.U. vitamin A per pound) the pen with the highest hatchability figure looked as vigorous as the other two pens when hatched. However, during the first 10 days about 30% of the chicks died and of the remaining 70% about one third appear to be permanently stunted. This would seem to indicate that

1000 International Units of vitamin A per pound of feed is not a sufficiently high level to produce eggs suitable for the production of strong healthy chicks.

SUMMARY

During the first two weeks of storage the rate of destruction of carotene was more rapid than that of vitamin A, but the rate slowed down and leveled off after this period. However, the initial loss of vitamin A was slower than that of carotene, but it continued to drop at a more rapid rate after two weeks. At the end of eight weeks 61.5 percent of the vitamin A remained, whereas at the twelve week interval only 37 percent of the original amount was left. In the carotene groups, the higher level (2029 International Units of vitamin A per pound fed as carotene) lost 36 percent of its carotene in the first two weeks. At twelve weeks 49 percent of the original amount still remained. The ration fed the group of chicks receiving the smaller amount of carotene (1228 International Units of vitamin A per pound fed as carotene) showed a loss of carotene of 36 percent during the first two weeks but thereafter the rate of destruction was considerably less than that of the other two groups. At the end of twelve weeks 62.5 percent of the original amount of the carotene still remained.

In the rat the established equivalence of carotene and vitamin A is 0.6 to 1.0. These data indicate that this ratio holds true in the feeding of poultry.

The chicks which received 1228 International Units of

vitamin A as carotene per pound of feed consumed showed about a 25 percent less growth response than that of the control group (2000 International Units of natural vitamin A per pound). This feeding level for carotene was approximately 30 percent less than that of the control group.

Superior feathering of broilers was obtained in this experiment by feeding vitamin A in the form of a carotene extract from alfalfa.

No deficiencies in fleshing were noted regardless of whether carotene from alfalfa or natural vitamin A was fed at equivalent levels.

Normal egg production was obtained at a level of 3000 International Units of natural vitamin A per pound of feed. Equally good egg production was obtained when the pullets were fed 3000 International Units of vitamin A as carotene from alfalfa per pound of feed. There was little difference in egg production at the feedihg level of 1000 International Units of natural vitamin A per pound of feed. There seems to be no advantage in feeding three times this amount for egg production alone. To obtain good, strong, healthy chicks a higher level of vitamin A is indicated by the hatchability and viability data.

BIBLIOGRAPHY

Almquist, H.J. Mackinney, G. and Mecchi, E. The Diet of Hens and the Vitamin A Potency of Their Eggs. J.B.C. 150: 99-105, 1943.

Bolin, D.W. Lampman, C.E. and Berg, L.R. The Influence of Carotene Intake as Supplied by Dehydrated Alfalfa on the Storage of Vitamin A and Pigments in the Livers of the Young Chicks. Poultry Science, 22, No.5, 1943.

Chichester, D.F. Russell, W.C. and Hudson, C.B. Mortality in Poultry Flocks and Vitamin A Content of the Livers of Pullets and Hens. Poultry Science, 17, No.6, 1938.

Ewing, W.R. Handbook of Poultry Nutrition. W.R.Ewing Publishing Co., 1943.

Fraps, G.S. and Sherwood, R.M. The Vitamin A Requirements of Hens for Egg Production. Texas Agr. Exp. Sta. Bull. 514, 1935.

Fraps, G.S. Kemmerer, A.R. Losses of Vitamin A and Carotene From Feeds During Storage. Texas Agr. Exp. Sta. Bull. 557, 1937.

Fraps, G.S. Meinke, W.W. Reiser, R. and Sherwood, R.M. The Carotene Consuming Power of Certain Feeds. Texas Agr. Exp. Sta. Bull. 637, 1943.

Hays, F.A. and Sanborn, Ruby. Breeding Rhode Island Reds For Rapid Feathering. Mass. Agr. Exp. Sta. Bull. 396, 1942.

Mussehl, F.E. and Akerson, G.W. Vitamins for Poultry. Nebraska Agr. Exp. Sta. Circ. 81, 1946.

Peterson, W.J. Hughes, J.S. and Payne, L.F. The Carotenoid Pigments. Kansas Agr. Exp. Sta. Tech. Bull. 46, 1939.

Record, P.R. Bethke, R.M. and Wilder, O.H.M. Preliminary Observations on the Vitamin A Requirements of Laying Birds. Ohio Agr. Exp. Sta. Bull. 579, 1939.

Record, P.R. Bethke, R.M. and Wilder, O.H.M. Vitamin A Requirements of Chicks With Observations on the Comparative Efficiency of Carotene and Vitamin A. Poultry Science, 16, pp. 23-25, 1937.

Ringrose, R.C. Norris, L.C. The Study of the Vitamin A Requirements of Chicks During Early Life. Poultry Science, 15, 390, 1936.

Rubin, Max and Bird, H.R. Some Experiments on the Physiology of Vitamin A Storage in the Chick. Poultry Science, 20, 291-297, 1941.

Rubin, Max and Bird, H.R. The Apparent Antagonism Between Vitamin A and Carotenoids in the Fowl. U. S. Bureau of Animal Industry, Science, 103, (2680): 584, 1946.

Russell, W.C. and Taylor, M.W. The Relation Between Vitamin D and A Intake by the Hen and the Output in the Eggs. J. Nutrition, 10, No.6, 1935.

Russell, W.C. Platt, C.S. Taylor, M.W. and Chichester, D.F. The Vitamin A Requirements of the Laying Pullet. N.J. Agr. Exp. Sta. Bull. 369, 1936.

Schroeder, C.H. Higgins, W.A. and Wilson, W.O. Vitamin A Requirements of Poultry - Paper Presented at Durham, N.H. Poultry Science Meeting 1935.

Sherwood, R.M. and Fraps, G.S. The Quantities of Vitamin A Required by Pullets for Maintenance and Egg Production. Texas Agr. Exp. Sta. Bull. 468, 1932.

Sherwood, R.M. and Fraps, G.S. The Amount of Vitamin A Potency Required by Hens for Egg Production. Texas Agr. Exp. Sta. Bull. 493, 1934.

Sherwood, R.M. and Fraps, G.S. The Quantities of Vitamin A Required by Growing Chicks. Texas Agr. Exp. Sta. Bull. 528, 1936.

Sherwood, R.M. and Fraps, G.S. Requirements of Chickens For Vitamin A When Fed as Carotene. Bull. 583, 1940.

Titus, H.W. Yearbook of Agriculture for 1939. Practical Nutritive Requirements of Poultry, 1940.

Tepper, A.E. and Durgin, R.C. Vitamin A Requirements of Growing Chicks. New Hampshire Agr. Exp. Sta. Bull. 310, 1931-37.

Wells, Jr., J.G. and Davidson, J.A. The Comparison of Carrots, "Greenmelk" and Dehydrated Alfalfa Leaf Meal in the Laying Ration. Mich. Agr. Exp. Sta. Quarterly Bull. 22, No.3, 1940.

Wells, Jr., J.G. and Davidson, J.A. Carrots Used For Green Feed Substitute. Mich. Agr. Exp. Sta. Quarterly Bull. 23, No.3, 1941.

Williams, J. K. Lampman, C.E. and Bolin, D.W. The Efficiency of Carotene as Supplied by Alfalfa Meal in Meeting the Vitamin A Requirements of Laying Hens. Poultry Science, 18, No.4, 1939.

ACKNOWLEDGEMENT

The author expresses appreciation to Dr. Carl R. Fellers, Professor Fred Jeffrey and Professor John Kuzmeski for their interest and help in this work; to Thorton Stevens, Poultry Plant Foreman, for his assistance in caring for the birds.

Approved by:

Carl R. Fellers

John W. Kluyveraki

F P Jeffrey

Date: June 4, 1947